

Appl. No. 10/707,559
Amdt. dated August 18, 2005
Reply to Office action of June 14, 2005

Amendments to the Specification:

Please substitute Title of the specification with the following amended Title:

5 **"IN-PLANE SWITCHING MODE LIQUID CRYSTAL DISPLAY HAVING
HEIGHTENED ELECTRODES"**

Please substitute paragraph [0004] with the following amended paragraph:

10 In a liquid crystal display, incident_light will [p]produce different polarization or_refraction when the alignments of liquid crystal molecules are different to produce gorgeous images. Since an LCD has the advantages of being lightweight, having low energy consumption, and being free of radiation emission, the LCD is widely used in various portable products, such as notebooks, personal data assistants (PDA), video cameras, etc., and even has a great potential to replace the conventional CRT monitor.

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Please substitute paragraph [0009] with the following amended paragraph:

20 When the thin film transistor 26 is turned off, no voltage is applied between the first electrode 16 and the second electrode 18 and no electric field is formed. At this time, the longitudinal axis of the liquid crystal molecules 17 is in parallel with the rubbing axis of the first alignment layer 19a and the second alignment layer 19b. That means, the longitudinal axis

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of the liquid crystal molecules 17 is aligned [t]to the direction that is coincident with the polarized direction of the first polarizer 13a. Therefore, no light can pass through the second polarizer 13b, and the observer cannot see any light emitted from the IPS-LCD 10. As a result, a perfect dark state
5 of the IPS-LCD 10 is formed. When the thin film transistor 26 is turned on, the longitudinal axis of the liquid crystal molecules 17, affected by the electric [f]field, gradually rotates from the original alignment direction to the alignment direction that is parallel to the electric field. That means, an angle difference is formed between the longitudinal axis of the liquid
10 crystal molecules 17 and the polarized direction of the first polarizer 13a to allow light pass through, leading to a bright state of the IPS-LCD 10.

Please substitute paragraph [0010] with the following amended paragraph:

The conventional in-plane switching mode LCD can improve the
15 problem of narrow viewing angle, which usually brings limitation to the conventional twisted nematic LCD. However, an LCD only having the advantage of wide viewing angle is not sufficient for [t]today's requirement. When a voltage is applied between the pixel electrode and the counter electrode of the conventional in-plane switching mode LCD to
20 generate a corresponding electric field, the electric lines nearby the color filter of the top substrate will bend. Thus, the rotation of the liquid crystal molecules is not as expected to affect various performance of the LCD.

Please substitute paragraph [0013] with the following amended paragraph:

25 According to one aspect of the present invention, an in-plane switching

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mode liquid crystal display [c]comprises a bottom substrate, at least one first electrode, at least one second electrode, a top substrate, and a plurality of liquid crystal molecules. At least one pixel area is defined on an upper surface of the bottom substrate. The first electrode is disposed in
5 the pixel area on the upper surface of the bottom substrate, and the first electrode is a protrusion elongated along a first direction. The second electrode is disposed in the pixel area on the upper surface of the bottom substrate. The second electrode is a protrusion elongated along the first direction, and the second electrode and the first electrode are in an
10 interlaced arrangement. The top substrate is in parallel with and opposite to the bottom substrate. The plurality of liquid crystal molecules ~~are~~ is filled in between the bottom substrate and the top substrate. Wherein a longitudinal axis of the liquid crystal molecules is positioned along a second direction and is horizontally arranged between the upper surface of
15 the bottom substrate and a lower surface of the top substrate, and an angle is formed between the second direction and the first direction.

Please substitute paragraph [0014] with the following amended paragraph:

Since an in-plane switching mode liquid crystal display according to
20 the present invention heightens the pixel electrode and the common electrode with a bump, the electric lines of the biased electric field between the pixel electrode and the common electrode are straightened to accelerate the rotation of the liquid crystal molecules. Consequently, each of the liquid crystal molecules rotates to the expected angle earlier.
25 Therefore, not only is the problem of the narrow viewing angle which always occurs in a conventional twisted nematic liquid crystal display

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improved, but also the driving voltage is reduced to improve the driving velocity and the transmittance of the in-plane switching mode liquid [c]crystal display.

5 Please substitute paragraph [0019] with the following amended paragraph:

Fig.4 and Fig.5 are cross_sectional schematic diagrams of the in-plane switching mode LCD along line 4-4' of Fig.3.

Please substitute paragraph [0019] with the following amended paragraph:

10 It is worth noticing that the second electrode 108, used as the pixel electrode, and the first electrode 106, used as the common electrode, are both protrusions elongated along a first direction 123. Both of the first electrode 106 and the second electrode 108 comprise a bump 130 and a
15 conductive layer 129 disposed on a surface of the bump 130. Each conductive layer 129 may be only disposed on the top surface of each bump 130 (as shown in Fig.4 and Fig.5), or be disposed on the top surface and the lateral surface of each bump (not shown). A width of both of the first electrode 106 and the second electrode 108 is approximately $3-8\mu\text{m}$.
A spacing between each branch 106a, 106b, 106c of the first electrode 106
20 and each branch 108a, 108b of the second electrode 108 is approximately $8-16\mu\text{m}$. A height of each bump 130, composed of a transparent material, is approximately $0.5-2\mu\text{m}$. Each conductive layer 129 disposed on the surface of each bump 130 is composed of a transparent material to increase the aperture ratio and the transmittance of the

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IPS-LCD 100. Actually, the material compositions of the bump 130 and the conductive layer 129 are not limited to transparent materials, and non-transparent material is able to be adapted.

- 5 Please substitute paragraph [0030] with the following amended paragraph:

Please refer to Fig.8. Fig.8 is a cross sectional schematic diagram of an in-plane switching mode LCD 200 along line 4-4' of Fig.3 according to a second preferred embodiment of the present invention. As shown in Fig.8, each of pixel electrodes 212 and common electrodes 216 comprises a bump
10 230 in a shape of a triangular prism and a conductive layer 229 disposed on a surface of the bump 230. A width of both of the pixel electrode 212 and the common electrode 216 is approximately $3-8\mu\text{m}$, and a spacing between each branch of the pixel electrode 212 and the common electrode 216 is approximately $8-16\mu\text{m}$. The bump 230, having a height of
15 approximately $0.5-2\mu\text{m}$, is composed of a transparent material. Furthermore, the conductive layer 229 disposed on the surface of each bump 230 is also composed of a transparent conductive material to increase the aperture ratio and the transmittance of the IPS-LCD 200. In fact, the material compositions of the bump 230 and the conductive layer 229 are
20 not limited to transparent materials; non-transparent material is able to be adapted. Since the operation principle of the IPS-LCD 200 in Fig.8 is the same as the principle mentioned in Fig.6 and Fig.7, it is not mentioned redundantly.

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Please substitute paragraph [0031] with the following amended paragraph:

Please refer to Fig.9. Fig.9 is a comparison chart of voltage-transmittance curves of the present invention IPS-LCDs 100, 200 and the prior art IPS-LCD 10 having no bump. In Fig.9, the width of both
5 of the pixel electrode and the common electrode is 4μ [μ]m, the spacing between each branch of the pixel electrode and the common electrode is 4μ [μ]m, and a cell gap is 4μ [μ]m. By utilizing these common parameters, simulation is executed to obtain the curves. In curve A, both of
10 the pixel electrode and the common electrode are in a shape of a traditional rectangular prism, and no bump is disposed at the bottom of them; in curve B, both of the pixel electrode and the common electrode are in a shape of a traditional rectangular prism, and a bump having a height of approximately
15 1μ [μ]m is disposed at the bottom of each of them; in curve C, both of the pixel electrode and the common electrode are in a shape of a triangular prism, and a bump having a height of approximately 1μ [μ]m is disposed at the bottom of each of them.